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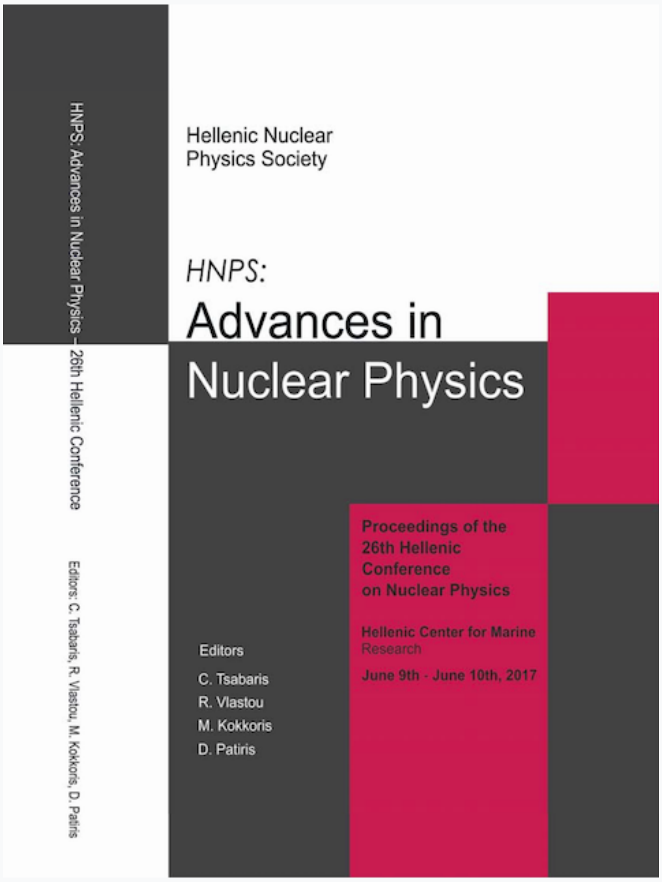

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Building an Analog Polarity Alternator for Electromagnets used in Nuclear Structure Experiments

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Abstract Electromagnets are essential components of experimental setups used in accelerator science and nuclear physics studies. In case of studying the interaction between a magnetic field and a particle's spin, electromagnets are almost always used, often with alternating polarities of the applied magnetic field. The change ofthe field polarity can be made manually or automatically. In this project, an automatic analog controller able to change the polarity of the magnet's voltage at predetermined instances was built from scratch. The controller uses a pair of microprocessors and a few transistors, making a programmable toolcapable of changing the polarity of any magnet working at 16V. The controller is mounted inside aNIM-1U module that can be fitted in a common NIM console. The unit is also equipped with polarity LED indicators and a switch with pre-programmed steps for changing the time instances the magnet changes. Tests of the controller coupled to an electromagnet dedicated for *g*-factor measurements are also reported.

INTRODUCTION AND MOTIVATION

Electromagnets are essential components of experimental setups used in accelerator science and nuclear physics studies. In case of studying the interaction between a magnetic field and a particle's spin, electromagnets are almost always used either as devices providing large external magnetic fields (e.g. in β-NMR or TDPAD studies) or as devices used to polarize internal fields (e.g. in the Transient Field technique).

It is often necessary to operate them at alternating polarities of the applied magnetic field to avoid possible systematic effects during experiments. The change of the field polarity can be made manually or automatically. In this project, an automatic analog controller able to change the polarity of the magnet's voltage at predetermined instances was built from scratch, to support future experiments with the Transient Field technique. The controller was further tested to check on its operation stability and integrity.

SPECIFICATIONS

The controller is based on an H-bridge circuit philosophy, constructed out of a few BS-170 transistors, some resistances and four PN diodes. The device uses as a main microcontroller an Atmel Atmega 8515 8-bit, programmable in C language, making a tool capable of changing the polarity of the existing (or any) magnet working at 16 V. The system uses an external 4 MHz clock for more accurate time calculation and a 5 V voltage divider as a power supply to the microcontrollers. It also has a 6-pin socket for connecting to the

Atmel's programming tool and a serial port output for live voltage values information. Finally there are some LED indicator and switches contacts.

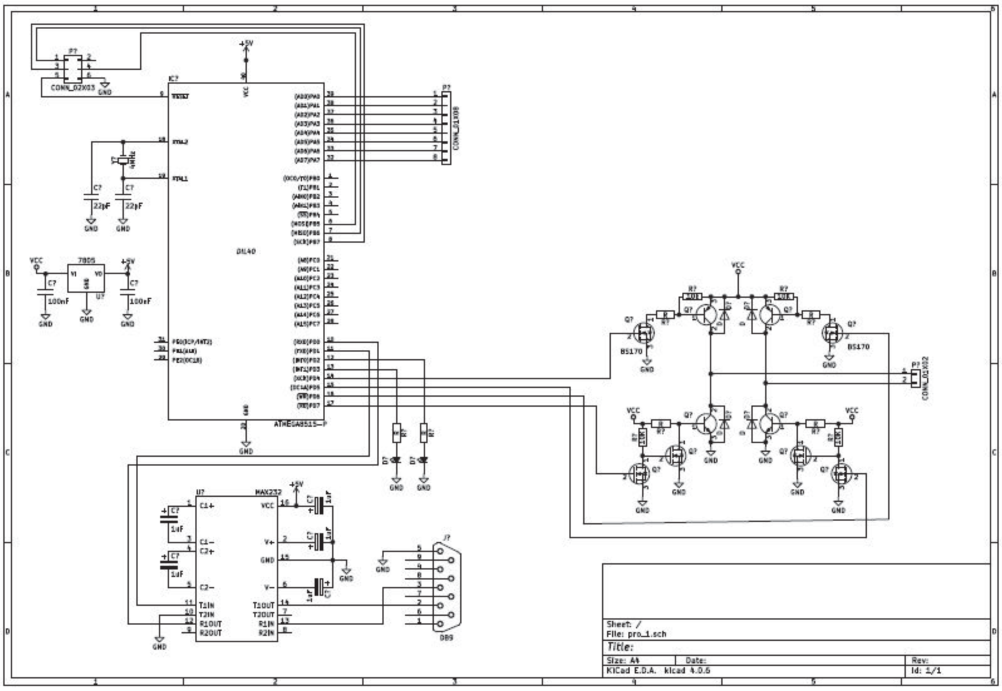

Fig. 1. The electronic circuit

THE ENCLOSING CASE

The controller was mounted inside a NIM-1U module (Fig. 2), which can be fitted into a common NIM crate. It's equipped with power and voltage LED indicators, 16 V input-output plugs, on/off and time selection switches and a serial port for connectivity. In this work, the time steps to reverse the magnetic field direction were programmed to 10 min and 20 min, but they can be changed easily for the needs of every experiment.

FIRST TESTING

For the actual test, the controller was tested on a split-pole electromagnet (diameter 16 cm) with a connecting iron yoke at the UoA lab. The controller was tested extensively in stand-alone mode before being connected to the electromagnet to ensure stable operational capacity. The test was performed with a time step of 10 min per field polarity. The magnet was also connected to a circulating water line for heat abduction. In total, three (3) full cycles of voltage alternations have been run. We used a 15.5 V power supply and maximum current of 200 mA. The magnetic field was measured at the middle point between the poles using a PHYWE teslameter. Values ranged between +28 mT and -28 mT.

Fig. 2. The enclosure

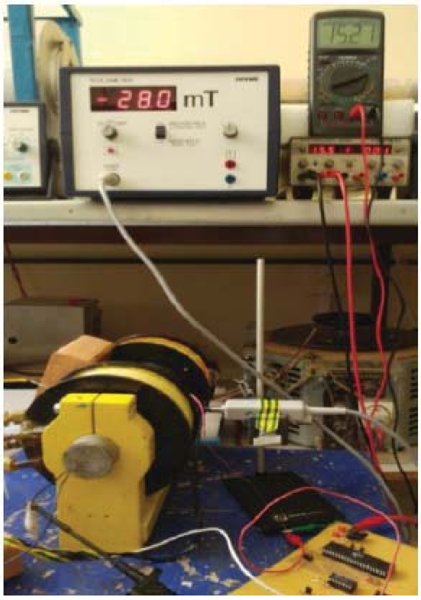

Fig. 3. The experimental setup, made by a dc power supply set to 15.5 V connected to the controller, which supplies the electromagnet. Using a magnetic probe the magnitude is measured with the teslameter. A slight voltage drop due to circuit resistance is apparent in the multimeter.

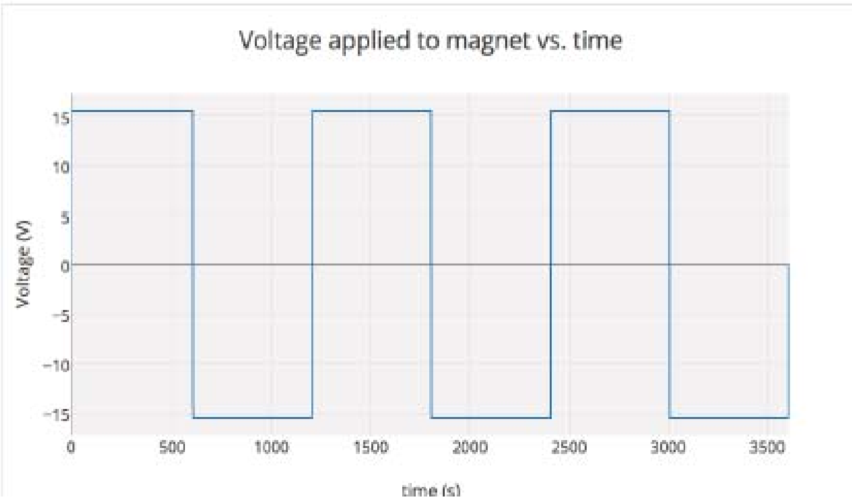

Fig. 4. Applied voltage time series. Field was flipped every 10 min with a 1 s zero-voltage interval to allow for reaching the hysteresis curve plateau.

CONCLUSIONS

A magnetic-field alternator controller was designed and built from scratch. The device was tested *in operando* and found to work flawlessly. Some minor refinements are still needed before deploying the device into real experimental conditions.

Acknowledgments
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